ProspecFit: In Situ Evaluation of Digital Prospective Memory Training for Older Adults

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Prospective Memory (PM), which involves remembering to perform intended actions, is the primary source of everyday memory lapses. While existing solutions mostly focus on supportive memory aids and reminders, it is also crucial to maintain PM functions and independent living for older adults. We present ProspecFit, which digitises *implementation intentions*, a lab-based memory intervention, making it available on smartphones through iterative design that draws insights from a focus group and preliminary studies. We evaluated its usability and effectiveness in enhancing PM through user studies that included a 12-day *in situ* study, and pre- and post-testing with 10 adults (61 to 80 years old). Participants in the digital PM training group were more prompt in performing the in situ PM tasks, compared to the control group without digital training, and reported improvement in their PM compared to before the training. We also show findings from diary entries, reports on forgetful moments and user reactions. Our work provides implications for creating digital memory training tools in HCI.

CCS Concepts: • **Human-centered computing → Empirical studies in ubiquitous and mobile computing**; *Smartphones.*

Additional Key Words and Phrases: Prospective Memory, Memory Training, In Situ Study

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1 INTRODUCTION

Prospective memory (PM) involves remembering to perform intended actions [17]. It is needed in daily activities, such as attending an appointment or taking medication, and is a key factor in maintaining quality of life and independence for older adults [26, 27]. However, PM lapses remain the most frequently reported in everyday forgetting [11, 42].

The most commonly used external PM aids are digital calendars, paper lists and post-it notes [4]. Existing research on PM interventions focus on supporting PM via 1) improving cueing systems to be just-in-time and leveraging on contextual awareness [13, 41, 44] or 2) introducing new cueing and notification methods or

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modalities like ambient and music cues [30, 35, 47, 56]. While it is crucial to support PM, it is also important to protect it through PM training, which could complement the use of memory aids, reduce age-related PM decline and lower the risk of cognitive diseases like Alzheimer's [51].

PM training has primarily been administered in lab conditions [7, 28, 52] or through computerised games [32, 45]. Making such training more accessible through mobile platforms would be beneficial for many. To allow for the transfer of the skills to the real-world, training should focus on application to real or naturalistic scenarios [7], while virtual tasks and games should be relevant to daily life [27].

We developed ProspecFit, a smartphone application (app) that guides users to practice and apply a memory strategy called "*implementation intentions*" to naturalistic tasks. This technique has been found to be effective at improving PM in adults [10]. With the prevalence of smartphones even among older adults, these devices are logical starting-points for administering digital PM training in-the-wild and for supporting in situ studies [36]. We contribute with:

- A digital translation of a lab-based memory training technique to a smartphone app, motivated by a focus group study with 8 older adults, where we describe how *implementation intentions* is digitally administered and its usability with 5 older adults.
- An in situ study and experiment designed to evaluate memory training through the app where we share the results from a 12-day field study with 10 older adults to investigate the app's effectiveness in improving PM.
- Insights for designing digital prospective memory training tools and systems.

2 RELATED WORK

2.1 Implementation Intentions

Implementation intentions, also known as the "when-then" technique, was developed by Gollwitzer [19]. It has been shown to improve PM performance and was mainly taught by researchers in lab settings [7, 10]. It involves two steps: 1) formulating/verbalising an "intention sentence" such as "When I leave home at 2 pm tomorrow, then I will bring Henry's gift.", and 2) visualising yourself performing the action. This method helps users to form stronger associations between situational cues (event, time or location) and intended actions [21], so that they are more likely to perform their PM tasks. The method was found to rely on automatic processes, which automatically cue the execution of intended actions once the situational cues are encountered and are less affected by age-related decline [20, 33]. This makes *implementation intentions* a viable method for improving PM in older adults. The strategy has been digitally translated to smartphones for a context-aware "when-then" intervention to support behaviour change and habit formation [40]. Brevers et al. [3] explored the feasibility of using *implementation intentions* to encourage intuitive eating and exercise through a smartphone app for patients undergoing obesity treatment. Our work expands upon these previous work, translating this method from a lab-based to digital training of PM via a smartphone app.

2.2 Memory Support Tools

Memory support tools are platforms for externalising our memory and for supporting our existing memory capabilities. PM support tools generally detect context using a variety of sensors and utilise the context to give timely cues. Dejaview [13] used a combination of sensors including camera, microphone and accelerometer to recognise the user's context and provided memory prompts in real-time. The wearable remembrance agent [44] proactively retrieved information from emails and notes taken to provide just-in-time cueing of relevant information based on the user's local context (e.g., location, people around, date, time). Previous work on PM support tools also innovated in cueing modalities and interaction techniques. Digital assistants, such as Google Assistant [22], could also be considered memory support tools which help to record and remind users of their tasks and events.

Wobble [56] used ambient and subtle visual and audio cues to remind users. Although these systems provide timely and convenient memory support, they might not improve our memory function [9] and would not be the focus of our work.

2.3 Memory Training through Digital Platforms

Memory training can be categorised into two types: process-based training and strategy-oriented training [5, 18, 27]. In process-based training, memory exercises are repeated, usually with increasing difficulty according to the user's performance. Commercially-available cognitive training programmes, such as BrainHQ [50] and Cognifit [49], use the process-based training approach to provide on-demand and portable training on computers and smartphones. BrainHQ was shown to improve auditory memory, while Cognifit was shown to improve working memory and executive function. More specific to PM, Lin et al. [32] created a virtual game for exercising PM that has tasks related to fishing and commerce. Rose et al. [45] used a computerised board-game, "Virtual Week", as a training tool for PM using tasks relevant to daily living, such as doing laundry and going for appointments. These tasks helped to improve the game's ecological validity.

In strategy-oriented training, the user trains on the use of a mnemonic strategy. Many digital strategy-oriented interventions focus on making these strategies more accessible. NeverMind [46], HoloMoL [54], memory palace project [25] and Physical Loci [39] allow users to digitally visualise and use the method of loci where individuals mentally associate physical objects (loci) in a familiar location to specific information. The Anki [16] program facilitates the spaced retrieval method, a method shown to enhance remembering in adults with dementia [8], using virtual flash cards in which new information is learned and tested over an increasingly longer period.

Our work aims to combine process-based and strategy-oriented training, by training the use of *implementation intentions* and facilitating its practice with naturalistic scenarios.

2.4 Evaluation of Prospective Memory Training

PM training has primarily been evaluated using pre- and post-testing in the lab, and in situ naturalistic assessments.

Evaluation of "Virtual Week" training [45] included pre- and post-testing of participants' performance in the game itself, and scores from the subjective Prospective and Retrospective Memory Questionnaire [12]. The training was also evaluated using the time accuracy (time difference between the actual and expected time of performance) on a naturalistic task, "call-back task", where participants had to remember to call the researcher 4 times at fixed time intervals from receiving a call from the researcher within a 2-hour slot [45]. To assess PM in real life and in situ, naturalistic tasks were adapted from "Virtual Week", and participants had to self-record completing 10 tasks for each of the 7 days in "Actual Week" [1, 43].

Liu and Park [33] guided participants to use *implementation intentions* for adherence to regular blood glucose monitoring, then recorded and evaluated the time accuracy (time difference between actual time and planned time) of using the glucose meters. Burkard et al. [7] evaluated their *implementation intentions* training programme through pre- and post- testing of a single-item PM measure, and two naturalistic tasks of collecting a document and reminding psychologist to pass a message. They used a standardised post-training interview to gauge participants' understanding of the strategy and their usage of it in everyday life.

We utilised pre- and post-testing measures of PM to evaluate our proposed digital PM training. We also used naturalistic tasks for in situ evaluation of the training, evaluating PM performance with time accuracy as well.

3 DIGITAL TRANSLATION OF IMPLEMENTATION INTENTIONS

3.1 Focus Group Study

A 1.5-hour focus group with 8 older adults (M_{age} = 67.9, 4 female) was conducted as a formative part of our work to gain insights on the following discussion themes:

(1) Types of memory lapses faced in everyday life (most recently faced, most frustrating and most frequently faced lapses)
(2) Strategies used to tackle them, memory improvement strategies they currently use and the challenges in using these strategies
(3) PM and possible reasons behind PM lapses
(4) Tasks that are relevant to daily life, involving PM and online digital services (e.g., online banking)

A researcher took notes during the session. The discussion was audio-taped and transcribed afterwards to identify the insights described.

3.1.1 Memory Lapses: The discussed memory lapses that relate to PM include forgetting to take pills, mislaying and losing items, forgetting what they intended to do when transitioning to a new room. Other common lapses related to retrospective memory (memory of past knowledge and experiences) are forgetting names and topics of past conversations. These items discussed are consistent with previous literature on common memory lapses [11]. We confirm that PM lapses were indeed faced by many and were important to address.

3.1.2 Strategies and Challenges: In terms of current strategies to tackle these lapses, participants pointed out writing to-do lists, using calendars and reminders, putting items at a prominent place, making tasks (like taking pills) part of their routine, retracing and running through a mental checklist, and telling others to remind them. These are mainly external memory aids and common strategies that were reported in other studies [4, 29]. The challenges in using current digital tools and strategies discussed were that if there were changes in routine, technical aspects such as insufficient battery power on the smartphone, trouble with using the tool, being annoyed by reminders and the hassle of setting up reminders or writing things down. For memory improvement strategies, participants also mentioned doing puzzles and reading books on enhancing memory. One participant shared that she used Lumosity [24], a process-based cognitive training app, every day as she believes it helps her to strengthen her memory and cognitive abilities.

3.1.3 Reasons for PM Lapses: The group agreed that being distracted by other tasks caused many of their PM problems, this is also supported by literature [15]. Other reasons are having too much in mind, being too busy with other work and the lack of consequences for not doing intended tasks or rewards for doing them.

3.1.4 Design Considerations for Tasks: The group was led to discuss the types of online services they would use and the preferred digital platforms they used them on. All of the participants had done online shopping (e.g., on Amazon[1]) on an occasional basis, usually buying items as gifts for family or friends. Online grocery shopping was not done often. Online booking of flights, movie tickets, hotel rooms and events were other common tasks. Contest sign-ups were not well received and many were cynical about it, due to the worry of spam emails and perceived low chances of winning. Participants shared that they would normally sign up online for workshops and classes or as volunteers for events that they found interesting. Participants also shared about using online banking and top-up services. We modified the naturalistic tasks for the practice of *implementation intentions* to be more in-line with what they were familiar with or had encountered before. Tasks are explained in detail in the next subsection.

3.2 ProspecFit

ProspecFit was developed for smartphones running Android 4.2 and above. To practice *implementation intentions* for a naturalistic PM task, users were led through two steps (formulation and visualisation) as seen in Figure 1. The goal was for users to eventually adapt *implementation intentions* to tasks in their own lives after training.

[1] https://www.amazon.com/

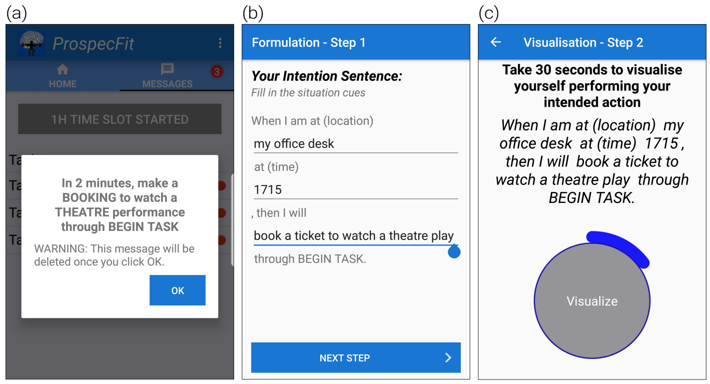

Fig. 1. ProspecFit app: a) Sample task instruction, b) Formulation (step 1) screen with three text fields to fill in, c) Visualisation (step 2) screen which displays the intention sentence from step 1 and allows user to start a 30-second timer

3.2.1 Naturalistic Tasks: PM tasks can be categorised into time-based (e.g., going for a doctor's appointment at 4pm) or event-based (e.g., buying groceries on the way home after work) [14]. We used an iterative design approach to develop these tasks. The initial task set was similar to tasks from previous work [1, 38, 43]. Since digital training was aimed at promoting independent living, we ensured that the tasks covered categories of independent activities of daily living: communication, finance management, shopping, lifestyle and health management [38]. We further refined them based on feedback from the focus group and from our preliminary studies (detailed in the next section 4.2). These were synthesised into 48 tasks. The full task list can be found in Appendix A. During an hour slot of the users' choosing, the app gave them 4 tasks a day to practice on. An example task is shown in Figure 1a. The app randomly draws these tasks from the task list in a Firebase database[2]. Thus, these tasks can be edited and expanded on to increase the number of tasks and types of tasks.

3.2.2 Formulation: In the formulation/verbalisation step (Figure 1b), users are shown a fill-in-the-blanks format sentence with three text fields to enter the appropriate situation cues (event, time or location) in an intention sentence for a given naturalistic task. This was designed to guide the use of more specific situation cues so that the method is more accurately applied [7]. These intention sentences are also stored in the Firebase database and can be edited to match the tasks. Once they were filled in, users can then move onto the next step of the method.

3.2.3 Visualisation: Previous research showed the average time for the visualisation step to be 30 to 45 seconds [7]. The visualisation screen (Figure 1c) instructs the users to take 30 seconds to visualise themselves performing the intended action with the situation cues in mind and shows them the intention sentence as entered in the previous step. The circular "Start" button starts a 30-second visual timer and tells users to "visualise". When the time is up, an alarm sounds and the button changes to an "OK" button which returns users to the home screen of ProspecFit (Figure 3a). The user can then go to the "Begin Task" web application to complete the related task (Figure 3e).

3.3 Usability Testing

To reveal any areas for improvement and points of confusion in using ProspecFit, we conducted Think-Aloud testing with 5 participants (M_{age} = 70, 3 male), where they verbalised their thoughts as they explored the user interface in one-on-one sessions that took about 45 minutes to an hour. Participants were given certain scenarios to act upon, to test the different functions of the app. A researcher facilitated the testing and noted down their

[2]https://firebase.google.com/docs/database/

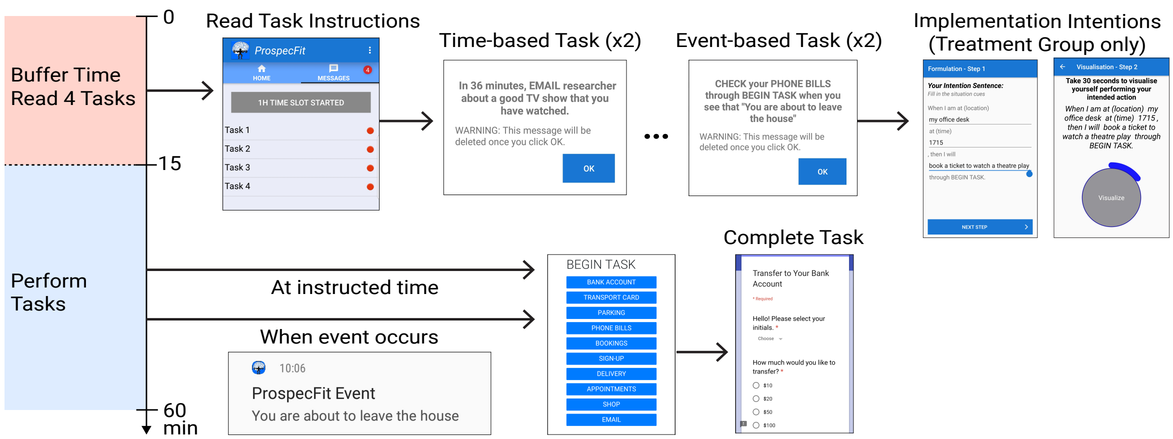

Fig. 2. Format of the 1-hour slots. Vertical axis indicates time from start of the 1-hour slot.

responses. The sessions were video recorded (with participants' consent) then coded and transcribed to elicit additional details. One major issue that emerged was that the soft keyboard obstructs some text fields during text entry. We observed that participants naturally tried to scroll up to see the rest of the text after entering what they wanted in one text field. The app was updated to address this usability concern such that the keyboard hides after users tap or scroll outside of the keyboard area. Participants were then given a System Usability Scale (SUS) [6] questionnaire. The mean SUS score was 77.5 (*SD* = 4.08), showing that ProspecFit's usability was in the acceptable range (80th to 84th percentile) [2].

4 EVALUATION

Given that *implementation intentions* method was effective in lab-based training, the aim of the study was to see if digital training using the method still worked through ProspecFit. We conducted a 12-day in situ study as well as lab-based pre- and post-testing. The study was a between-subjects experiment, where participants were randomly assigned to either the *treatment* group who underwent 6-days of digital training of *implementation intentions*, or the *control* group without the digital training.

The ProspecFit app was modified to support the extra functions for the study (e.g., task assignment, diary entry, forgetful moments), as well as to disable the digital training for the control group.

4.1 12-Day Tasks Design

Participants from both groups were given the same set of 48 naturalistic PM tasks (as introduced in Section 3.2.1) to perform in the in situ study. During each of the 12 days, participants were asked to perform four randomly-assigned tasks during a 1-hour (1h) slot, with 2 tasks of each type (event-based and time-based). Since participants included working professionals and community-dwelling retirees with limited time to commit to the study, this design respected their wishes to have the 1h time slot and to choose when to start it. This 1h slot system also followed the "call-back task" design that had a 2-hour slot [45].

As shown in Figure 2, the first 15 minutes were "buffer time" to read all four task instructions through ProspecFit. Each instruction could only be read once to ensure that they would not serve as reminders. Only the treatment group went through the two digital *implementation intentions* steps of formulation and visualisation, after reading *each* task for the first 6 days. Between the 15-minute mark to the end of the hour, participants were to complete the given tasks. The expected times to complete each task were randomly generated by the app and ranged from

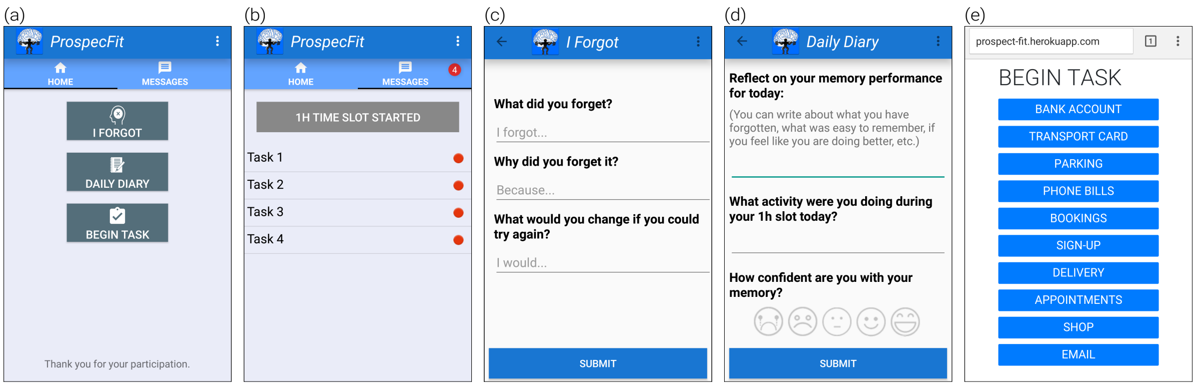

Fig. 3. a) Home tab, b) Messages tab, c) I Forgot screen, d) Daily Diary screen and e) Begin Task web application

20 to 45 minutes from reading the task. This delay between task instruction and performance was made to be similar to the naturalistic task by Burkard et al. [7], which had the delay of 20 to 40 minutes.

Time-based tasks required participants to check the time and *complete* the task as close as possible to the specified timing in the task instructions. An example of a time-based task is: "In 23 minutes, transfer money to your bank account". For each event-based task, a phone notification is created by ProspecFit at the randomly generated expected time and acted as the event (situational cue). An example of an event-based task is: "Email researcher to tell about your day when you see [the phone notification] that 'You have just returned home". Upon reading the event message, the participant would complete the related task as read earlier at the start of the 1h. This message did not remind participants of what task to perform and could not be too obvious that participants were able to guess the tasks to do [43]. Thus, messages were "You are about to leave house" / "You have just returned home". Only 2 event based tasks: Gift and Book shopping had the message "Go to GIFT Shop / Book Shop". This was done because the actual task was to remember to buy a specific item, while buying other items on a given shopping list.

To execute the tasks using ProspecFit, participants launched the "Begin Task" application (Figure 3e), which allowed them to choose the task to execute. Clicking on any task button in Begin Task, such as "Bank Account" and "Transfer" led to a Google Form to perform the task. Tasks were considered complete when they clicked "Submit" in the Google Forms or when they sent the email. Although "Begin Task" web app had an always-available list of actions to perform (similar to "Virtual Week" game [45]), each task instruction was different and read only once. Participants could not complete tasks with recognition alone, as one might recognise from the "Begin Task" list that one of the tasks involves emailing but fail to recall the exact time or event to send that email and the content to write.

4.2 Preliminary Studies

We conducted two preliminary studies to test the feasibility and to adjust the difficulty of the 12-day tasks. The first involved one-hour sessions in the lab with 4 participants who were given the same conditions as the *control* group (M_{age} = 72.3, 2 male). Participants were left on their own in the testing room during the hour to read and complete PM tasks. The second involved 3 participants (M_{age} = 55, 2 female) who remotely installed ProspecFit and went through the full 12-day study. 2 were in the treatment group and 1 in the control group. We determined the number of tasks per day for the final study to be 4, which showed an average of about 2 completed tasks out of 4 tasks per day across the 12 days (close to 50% accuracy) in the control group. This was important so that we would more likely be able to see and compare any differences in the accuracy between the groups. If the control group mostly completed all the tasks per day or none of them, then we might not be able to spot any differences. We verified that it was feasible to deploy ProspecFit in situ and its usability was acceptable [2] with a mean SUS score of 82.9 (*SD* = 6.0, within the 90th to 95th percentile) from the SUS questionnaires given to the participants in the preliminary studies, an increase in usability score compared to the mean SUS score of 77.5 (*SD* = 4.08, within the 80th to 84th percentile) in the Usability Testing Section 3.3. Six of the seven participants agreed and strongly agreed with the SUS statement "I think that I would like to use this app frequently". Key usability and feasibility concerns with ProspecFit were addressed before deployment to the actual study.

4.3 Participants

We recruited participants via email invitations, flyers and websites. To qualify for our study, participants were required to be native English speakers between 50 to 80 years, with normal or corrected-to-normal hearing and vision and Android smartphone users, familiar with computers and smartphones. Participants with a history of a neurological or major psychiatric disorder, brain injury, epilepsy, or who were taking psychoactive drugs were excluded from the study. 10 community-dwelling participants took part in the study (actual age range: 61 to 80 years, $M_{\text{age}} = 70$, $SD_{\text{age}} = 5$, 3 male), with 5 assigned to the *treatment* group. Ethical approval was obtained before our studies and participants gave their consent to use their data.

4.4 Apparatus

Participants installed ProspecFit on their own Android smartphones (which ranged from Android version 5.0 to 8.0). Upon launching the app, users see the Home tab (Figure 3a) where they can access the "I Forgot" section (Figure 3c), "Daily Diary" (Figure 3d) and "Begin Task" web application (Figure 3e). "Begin Task" was deployed through Heroku[3] cloud application platform. Users could start their 1h slot and read the four task instructions through the "Messages" tab as shown in Figure 3b. This was accessed from the Home tab by swiping left on the screen or tapping on the "Messages" icon. For the study, the "I Forgot" and "Daily Diary" sections were designed specifically not to show past entries, since they may serve as direct reminders for them.

4.5 Procedure

4.5.1 Pre-Test Session: Participants attended a lab-based pre-test session individually for 1 hour 30 minutes. They first went through the Montreal Cognitive Assessment (MoCA) [37], a 10-minute cognitive screening for mild cognitive impairment. They were then given the Prospective Retrospective Memory Questionnaire (PRMQ) [12], consisting of 16 questions to self-report the kinds of everyday memory lapses faced and how often (8 questions related to prospective memory and the other 8 to retrospective memory). A trained researcher administered the Cambridge Test of Prospective Memory (CAMPROMPT) [53], a 25-minute standardised test of PM, in which participants were given six PM tasks (3 time-based and 3 event-based). Participants were given a post-CAMPROMPT questionnaire to rate their perceived performance and strategies they used for CAMPROMPT. Subsequently, the treatment group were given the Vividness of Visual Imagery Questionnaire [34], to profile how well they could mentally visualise an image and given an introduction to *implementation intentions*. All participants were given the same instructions for the 12-day study, which explained the format of the 1h slot tasks, the diary study (that we termed as "Daily Diary") and reporting of forgetful moments (that we call "I Forgot" moments). Participants were instructed to continue with their own daily activities and not to use external memory aids during the 1h slot. Lastly, we ran a 15-minute dry run of the 12-day tasks through ProspecFit with participants to ensure they understood the instructions and how to use the app. The 12-day in situ study was split into two phases: Practice Phase and Transfer Phase.

[3] https://www.heroku.com/

4.5.2 Practice Phase: The first 6 days were considered the Practice Phase. Participants did the 1h slot tasks for each day, and also did daily diary entries and reported forgetful moments. The treatment group practised *implementation intentions* (formulation and visualisation steps) through digital training in ProspecFit after reading task descriptions in the first 15 minutes of the 1h slot.

4.5.3 Transfer Phase: The next 6 days followed a similar procedure as Practice Phase, except that the formulation and visualisation steps were remotely disabled and the treatment group did not undergo digital training. All participants were still to complete the tasks in the 1h slot. This was to determine if there were any transfer effects where the treatment group applied *implementation intentions* to the naturalistic PM tasks and daily life even after digital training. Participants were not informed of this part during the briefing.

4.5.4 Post-Test Session: Participants returned for a 1 hour 30 minute post-test session, within 5 days after day 12. They were given the PRMQ, CAMPROMPT and the post-CAMPROMPT questionnaire, same as with the pre-test. Participants in the treatment group were given a post-treatment quiz to test their understanding of *implementation intentions*. This was followed by a semi-structured interview to inquire on how they applied and would apply the method. Control group participants went through a semi-structured interview to report the strategies they used and to get their feedback on the study. We debriefed them, informing them that they were in the control group and explained *implementation intentions* to participants who wanted to know more. Lastly, participants were given an SUS questionnaire to fill in.

4.6 Measures

We compared the following dependent variables as measures to capture the effectiveness of the training across conditions:

- *PM Performance:* Measured objectively through the CAMPROMPT and 12-day Tasks
- *Frequency of Memory Lapses Reported:* Measured through the self-reported PRMQ and forgetful moments through "I Forgot" section in ProspecFit
- *Confidence in Memory:* Measured through the post-CAMPROMPT questionnaire, diary study and interviews
- *Understanding of Implementation Intentions:* Measured through the post-treatment quiz and interviews (for treatment group only).
- *Application of Implementation Intentions:* Measured through the diary study and interviews (for treatment group only).

4.7 Data Collection

ProspecFit logged timestamps of when the tasks were read and recorded responses for the "I Forgot" (Figure 3c), "Daily Diary" screens (Figure 3d), and intention sentences formed in a Firebase database. Timings and responses to tasks were collected through Google Forms. Email-related tasks and their timings were received through a university-based email. The interviews were audio-recorded and transcribed by an external coder.

5 RESULTS

5.1 Pre-Post Testing

The standardised PM test, CAMPROMPT, was scored out of 36 where a higher score indicated a better PM performance. The self-rated CAMPROMPT performance followed a 10-point Likert scale, where 10 indicated that participant felt he/she did extremely well in CAMPROMPT. We report PRMQ True Scores for prospective component, where a higher score reflected higher self-rated PM.

We conducted the Wilcoxon signed-rank test to compare differences in pre-post scores. We found no significant change in the pre- and post- CAMPROMPT scores for the treatment group (pre: *median* = 21, post: *median* = 28,

$T = 3$, $p = .22$) and for the control group (pre: *median* = 25, post: *median* = 27, $T = 7$, $p = .89$). We also found no significant change in pre- and post- self-rated CAMPROMPT performance for the treatment group (pre: *median* = 6, post: *median* = 6, $T = 10.5$, $p = .41$) and control group (pre: *median* = 5, post: *median* = 7, $T = 1.5$, $p = .10$). There was a significant increase between pre- and post- PRMQ prospective scores for the treatment group (pre: *median* = 44, post: *median* = 46, $T = 0$, $p = .041$), but not for the control group (pre: *median* = 50, post: *median* = 48, $T = 10$, $p = .50$). This indicates that the treatment group felt that their PM were doing better compared to before the digital training.

5.2 12-Day Study

There were two dimensions of the participants' responses in the 12-day study: time and accuracy. A response was considered to be accurate only if it was performed exactly once, without repeated responses. Based on that, we define the following possible outcomes of a response:

- *correct*: a response is on time and accurate.
- *wrong*: a response is on time but inaccurate.
- *late*: a response is more than 5 minutes after the expected time for time-based tasks and more than 15 minutes for event-based tasks, regardless of its accuracy.
- *too early*: a response is before 5 minutes of a time-based task and before the event, regardless of its accuracy.
- *missing*: the user never responded to the task.

5.2.1 Promptness of Responses: To determine the effect of the digital training, we compared the *promptness* of responses, which is the time difference in minutes between expected and actual response time to the 12-day tasks. A Mann-Whitney U test showed a significant difference in *promptness* for all responses between treatment group ($n = 5$, *median* = 2.6) and control group ($n = 5$, *median* = 5.7): $U = 2$, $p = .028$. When analysing the responses for time-based tasks, the treatment group (*median* = 1.6) had a significantly lower time difference than the control group (*median* = 3.2): $U = 3$, $p = .047$. When comparing event-based tasks, the treatment group (*median* = 3.0) also had a significantly lower time difference than the control group (*median* = 5.4): $U = 3$, $p = .047$. Results are shown in Figure 4.

5.2.2 Promptness over Time: Consistent with the results of the overall promptness, the treatment group was more prompt (less time difference) in their responses than the control group across the 12-days (Figure 5, top) and even during the first 6 days of digital training of the technique in the Practice Phase. Despite the lack of a noticeable trend of increasing promptness over the days, we observe that the control group became almost as prompt as the treatment group on days 7 to 9 but became less prompt towards the end of the study. The treatment group had lower time difference for their responses to time-based tasks compared to event-based tasks except on day 12 (Figure 5, bottom).

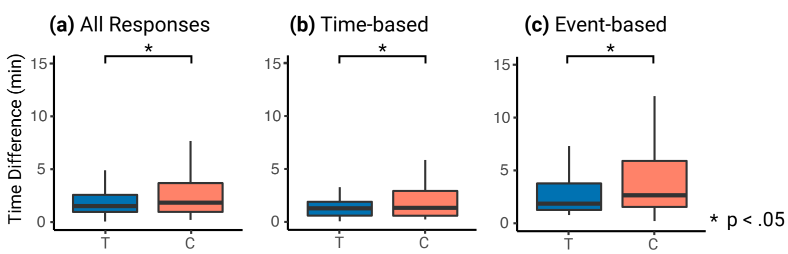

Fig. 4. Time difference between response and expected time of response for a) All responses, b) Responses to time-based tasks and c) Responses to event-based tasks, for treatment group (T) and control group (C).

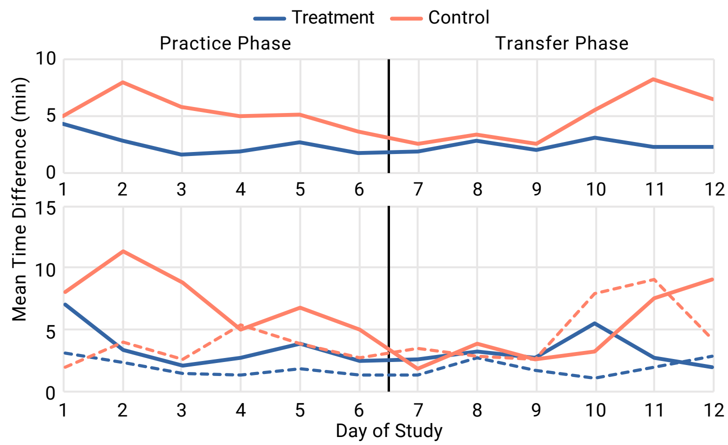

Fig. 5. Mean time difference (promptness) of responses across the days for all responses for each group (top chart) and for the two types of tasks (bottom chart, solid lines: *time-based tasks*, dashed lines: *event-based tasks*). Vertical lines between day 6 and 7 indicate the separation between the practice and transfer phases.

5.2.3 Accuracy of Time-based and Event-based Tasks: Figure 6 shows the percentage of correct responses for the treatment and control group, for event and time responses, as well as for correct event and time responses. A Mann-Whitney U tests showed no significant difference between the number of correct responses for *a)* treatment (*median* = 38) and control (*median* = 34): U = 20.5, p = .09, *b)* event (*median* = 17) and time (*median* = 18.5): U = 44, p = .64, *c)* treatment-event (*median* = 17) and treatment-time (*median* = 21): U = 6.5, p = .20, *d)* control-time (*median* = 16) and control-event (*median* = 16): U = 14, p = .75, *e)* treatment-event (*median* = 17) and control-event (*median* = 16): U = 16, p = .46, and *d)* treatment-time (*median* = 21) and control-time (*median* = 16): U = 20, p = .11.

5.2.4 Accuracy over Time: We expected a trend of improvement in accuracy during the Practice Phase for the treatment group as a result of the digital training of *implementation intentions*. However, this was not the case as seen from the mean number of correct responses (out of 4) for each group across the days (Figure 7). The

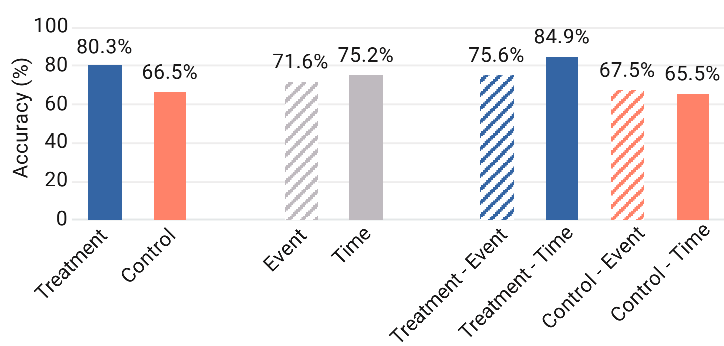

Fig. 6. Percentage accuracy of responses (percentage of correct responses): left two: *treatment* vs. *control*; middle two: *event-based tasks* vs. *time-based tasks*; right four: {*treatment*, *control*} × {*time-based tasks*, *event-based tasks*}

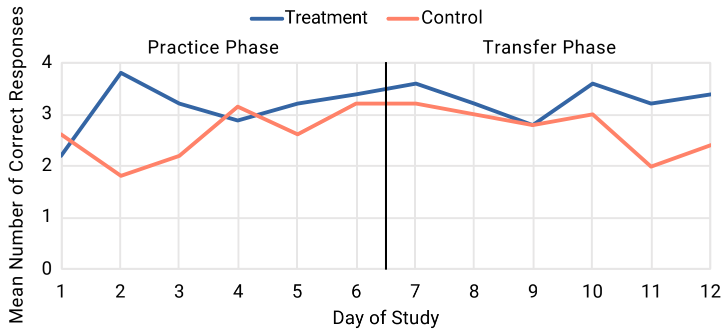

Fig. 7. Mean number of correct responses across days for treatment and control group

treatment group had a higher mean number of correct responses than the control group across most of the days, except for days 4 and 9. The general lack of strong learning effect and the overall superior PM performance in the treatment group might indicate that the digital training of *implementation intentions* had an immediate effect and that the participants quickly learned the method.

5.3 Diary Study

Reflections could be categorised into four themes: tasks, strategies, daily life and confidence. For reflections about the 1h slot, participants usually attributed their memory performance for the day to their perceived performance for the tasks. P1 (treatment, day 2) mentioned that *"Memory performance was good today I think. I remembered all my tasks and did them at the right time"*. Some reflected on making a mistake in a task or noted a reason for the mistake. Regarding using the *implementation intentions* memory strategy, P2 (treatment) stated that he was *"Getting better with visualising tasks"*, reflecting on a perceived improvement in how he was using the strategy. There were reflections from the control group about other strategies used for helping them to perform the 1h slot tasks. P8 (control) said *"I tried a different strategy for remembering tasks today which was sort of effective. I will continue with strategy for a couple of days before I decide."*. Participants also reflected about remembering a task in their daily lives: *"Went to Family History Expo final wrap-up meeting this morning. Remembered all the points I needed to make without notes. Now planning for next year's Expo."* (P2, treatment) and *"Remembered to prepare run sheet for tomorrow's meeting. Used pre-written notes to cover all points."* (P6, control). A few participants also recorded about their confidence in their memory: *"Moving from confident to very.... it is getting easier, therefore I don't worry about forgetting.... an(d) the cy(c)le continues"* (P4, treatment). Participants rated their confidence in their memory for each day on a 5-point Likert scale in the diary (1 = Not confident at all, 5 = Very confident). However, we found no trend in the confidence for each group and between the groups.

PM tasks often involve the presence of an ongoing distractor task which, in this case, is the daily activity that the participant did during the 1h slots [43]. Participants entered these activities in the diary for each day. The most common activities were working on the computer and watching TV, followed by reading and having or preparing a meal. The leisure activities mentioned by participants were consistent with previous studies [31], in which, watching TV, playing games on the computer or phone and reading were the top activities reported. Other activities include doing housework, talking with others, using the phone and travelling. We confirmed that doing the activity "using phone" did not result in "correct" scores for 6 of the 7 instances, which indicates that they were sufficiently distracted by this activity and it did not contribute to unfairly high performance in the 1h tasks.

5.4 Forgetful Moments

Participants reported four types of forgetting: prospective, episodic, semantic and attention. A total of 62 forgetful moments were reported through the "I Forgot" section in ProspecFit by 9 participants, one participant did not report any. Of these, 45 were related to prospective memory (72.6%), 10 related to attention, 7 related to semantic memory and 3 related to episodic memory. 4 reports included two types of forgetting. Prospective memory forgetting included incidents in daily life, such as *"I forgot to ring my son back."* (P7, control), other incidents were about forgetting to perform tasks related to the study. Following definitions of attention lapses from previous research [11, 42], such lapses related to moments of confused intended actions and incidents that resulted from not paying attention, we can see this for P2 (treatment) who mentioned, *"...I had left the electric jug filling and it overflowed."*. Episodic memory forgetting related to personal experiences and information: *"Whether [I] had completed all four tasks"* (P8, control). Semantic forgetting related to forgetting words, names and learned facts. P4 (treatment) reported an episodic and semantic forgetful moment, *"The name of the dish I ate [during] (S)unday lunch"*. The treatment group reported a lower number of forgetful moments of 18, compared to the control group who reported the remaining 44 incidents.

5.5 User Reactions

5.5.1 Confidence: In the semi-structured interviews, participants noted being more confident about their memory (P1, P4, P5 from treatment and P6, P8 from control). However, confidence did not seem to correlate with the participants' PM performance. In many cases (e.g., P2, P4 from treatment and P6 from control), their reflections contradicted the self-rated confidence level in the same day's diary entry. Therefore, despite having some participants (P1 from treatment and P7, P9 from control) demonstrate good agreement between their confidence level, actual performance and self-reflection, we consider confidence to be a non-deterministic factor in memory performance. Participants (P3, treatment and P8, control) expressed their need for digital feedback about the outcome of the tasks (whether tasks were completed and if they had got them correct). We point out that not providing feedback on the outcome of tasks in our study in the first place, actually allowed for the opportunity to reveal this disparity between perceived and actual performance.

5.5.2 Understanding and Transfer of Technique: Four out of five in the treatment group (except P3) mentioned in their diaries that they continued to use *implementation intentions* for remembering to perform the tasks and diary during the transfer phase (even after digital training): *"Performance was good today. I found it easier to remember the tasks today. I also practised the method to remember to do this diary"* (P1, day 8). This shows some evidence of transfer. The interviews further elicited that all participants in the treatment group noticed that the *implementation intentions* training stopped, four of them continued because they felt the strategy was helpful and wanted to continue practising it on their own. By analysing the post-treatment quiz, we found that P3 did not seem to use the intention sentence format accurately when answering one of the questions asking to form an intention sentence for a sample scenario. She specified the event but not the location cue and did not use the "When I... then I will..." structure: *"After dinner tonight, remember to take medication."*. Despite improved PM performance when using the method, P3 seemed to have a limited understanding of it, especially regarding the formulation step.

5.5.3 Vividness of Visual Imagery: Interviews with the treatment group revealed that P2, P3, P5 highly valued the visualisation step and felt it was the most crucial part of the method, while the other two participants (P1 and P4) found it hard to visualise and focused more on the intention sentence from the formulation step. This observation agrees with their self-rated vividness of visual imagery score (highest vividness score is 160): the low vividness of 37.5 and 32 for P1 and P4, compared to the average vividness of 69, 80 and 78 for P2, P3 and P5 respectively. Thus, users had different affinities to the different steps of *implementation intentions*.

5.5.4 Adaptation and Integration of Memory Strategies: From the diary entries and interviews, we found that P1, P4 and P5 incorporated *implementation intentions* into their lives and adapted it to fit with existing strategies they were using. This presents another evidence of transfer. P1 combined the strategy with repetition: *"I am not good at visualisation but [I] used it as a starting point and used repetition in my mind to remember."*. P5 and P4 tried using the strategy for the 1h slot tasks by forming a story with them and associating them to real life. P5 reflected in her diary (day 3): *"My four tasks I found easy today because visual(i)sed 1 or 2 words for each task and made a story from them."*. She visualised herself in a mental story where she encounters these cues (words associated with the task). P4 liked that *implementation intentions* reinforced intended actions and found the formulating step helpful. She wrote in her diary (day 10), *"Felt quite confident tonight... tried to repeat and visualize... adding details... what I would volunteer for and how I would transfer money... "*. She further elaborated in the interview that she would integrate the idea of forming more concrete and precise intended actions (from *implementation intentions*) to her routine of writing her daily tasks at the start of the day. These adaptions made the method more relatable, allowing better transfer of the method to their daily lives. They also show the possibility of complementary use of training and external memory aids.

P6, P7 and P8 from the control group also developed or found their own strategies to tackle the 12-day tasks. P6 described in five diary entries about his technique and it was further discussed in his interview. It involved forming an acronym, such as "TEMP" when the tasks were "check **T**ransport card, **E**mail, sign-up for **M**embership and order **P**izza", and then ran through the letters of the acronym when recalling the tasks.

6 DESIGN IMPLICATIONS

6.1 Addition of Feedback

Although confidence might not directly impact performance, adding feedback of the outcome of tasks to future digital memory training tools might improve users' perceived utility of them, and encourage the continued use of the strategies and training.

6.2 Provide Better Guidance in Applying Strategy

Understanding or forming a mental model of how to use the method might be a critical factor to the degree of transfer (application) of the method to other scenarios and in real life. Since memory strategy training relies very much on user's ability to apply techniques [18], future digital memory training tools should ensure that the strategy is well-conveyed, meaningfully-practised and users are carefully guided through the different steps of the technique. To illustrate this using our case, ProspecFit might need to analyse sentences made and cues filled in, and provide feedback and suggestions on how to properly formulate the sentence as well as how visualisation could be done. This might allow for better understanding and therefore, a higher chance of transfer.

6.3 Use Different Modalities for Digital Training

The different affinities to the *implementation intentions* steps might be the reason why previous studies [7, 10, 33] use both verbalisation and visualisation. Digital assistants [22] and reminder systems [30, 35, 47, 56] use a mixture of audio and visual cueing and interaction modalities to support memory, while Anki [16] allows for audio output together with the flashcards for memory training using the spaced retrieval method. Future digitisation of strategies could likewise leverage on a variety of modalities to facilitate the training (e.g., audio, video). To illustrate, if the user is not able to visualise vividly, then ProspecFit might provide guiding audio to enhance the visualisation experience with phrases like "Imagine your surroundings, what do you see?" and "Imagine seeing the cue and performing your intended action".

6.4 Encourage Adaptation of Memory Strategies

Future digital memory training tools could encourage and allow users to adapt the techniques learnt as well as to document, evaluate, and share their own memory strategies. This could be a good complement to existing strategies that might facilitate the enhanced transfer of techniques.

7 DISCUSSION

7.1 Digital Memory Training Style

Previous lab-based training using *implementation intentions* showed training gains in PM [10], while Brom and Kliegel [5] showed that a combination of process-based and strategy-based training in the lab could reduce PM failures in older adults. With ProspecFit, we see a promising and feasible start in scaling a previously time-consuming and lab-based memory technique training to digital training, as well as combining process-based and strategy-based digital training. ProspecFit borrowed the micro-training style of process-based training tools [49, 50] that would allow for a reduction in time and effort for a single instance of training, and an increase in access and frequency of training. It might be possible to scale other strategies towards similar always-accessible and micro-training formats as displayed in our prototype, where users practice during time slots (e.g., 30 minutes, 1 hour) of choice. By using naturalistic tasks similar to those in Virtual Week [45], we also confirm that training *implementation intentions* on realistic content revealed signs of transfer to everyday tasks [27]. Further increasing the realism of the tasks in ProspecFit could enable users to relate to the tasks and apply the strategy to real-life situations better.

ProspecFit differentiates from other strategy-based tools [16, 39, 46] as the generalisable nature of *implementation intentions* unveils a wider range of applications compared to mnemonic techniques which focus on retrieval processes such as the method of loci [27]. Our current version could be easily modified to benefit other areas that are afforded by the *implementation intentions* technique, such as successful goal achievement, planning and habit formation in young and older adults [3, 21, 40].

7.2 Complementary Roles of Memory Support and Memory Training Tools

Considering how P4 used the technique when writing down daily tasks, we could explore the possibility of merging memory support and training in one app. One approach would be to embed training in the existing commonly-used support systems [4]. The user experience and functionality of the app could transition from memory support to memory training, for example: The user starts with a to-do list or calendar app which could help manage, keep track and remind of tasks and events. The functionality could slowly switch to facilitating the memory strategy on the user's own tasks as the user enters them into the app.

ProspecFit could benefit from the just-in-time cueing and context awareness features of memory support tools. The app could use sensing techniques of memory support tools to take the user's surroundings as context [13, 41, 44], such as activity, time and location. Then, notify and suggest to start a memory training session when the user is in a suitable situation. By sensing the user's physiological context such as skin conductance and heart rate variability measures, the app could estimate the attention [55] and cognitive load levels [23] of the user, and then initiate training at times when the user has more calm and open to do so.

7.3 Limitations and Future Work

7.3.1 Time Frame and Number of Participants: Our study's time frame of 12 days might be too short to see concrete longitudinal effects. Further studies could determine longer-term training effectiveness, as well as to assess the transfer effects. We also note that our results may not be generalisable to a wider population but we hope that our findings would encourage further larger-scale studies regarding the development of other digital memory tools in this direction.

7.3.2 In Situ PM Assessment: Our objective measures were tied closely to the 12-day tasks which remain hypothetical. Despite our efforts to ensure naturalistic tasks were relatable, our tasks were confirmed as plausible by most participants except for P3 and P7 who felt that the tasks made little sense as they were not their own. Future work could customise tasks per participant, to better reflect what each participant might personally encounter. Another approach would be to use their own daily tasks as assessment or an integrated system that accommodates both given naturalistic tasks and personal tasks. Future experiments might consider physical tasks verified via sensors [48], that could be an answer for an objective yet more realistic measure of PM.

7.3.3 Immediate and Lasting Effect: Some studies have shown that a once-off application of *implementation intentions* had a lasting effect for as long as three weeks [33]. Our experiment seems to agree with such findings, revealing no trend of learning effect with *implementation intentions*. This could suggest that the method indeed relies more on automatic (subconscious) processes which are less affected by age-related decline [20, 33]. Future work could investigate other memory techniques which also tap into subconscious processes or investigate how to verify, reproduce, and quantify these immediate and lasting benefits of *implementation intentions*.

Despite the limitations, the digital memory training using ProspecFit had acceptable usability (M = 91.5, SD = 5.5, within the 96th to 100th percentile) as reported by the participants in the treatment group, and we show evidence of PM improvement and transfer of technique even with 6 days of digital training.

8 CONCLUSION

Prospective memory remains a concern for older adults. We presented a digital memory training of *implementation intentions* on a smartphone app: ProspecFit, which was closely designed with users from a focus group and preliminary studies, and we validated its usability. A 12-day in situ study, as well as pre- and post- testing with older adults were conducted to test its effectiveness. Despite the limited time frame and participants, our exploratory work to bring PM training from the lab to a digital platform showed signs that improvements in PM through training could still hold with digital training, allowing older adults to be more prompt in performing PM tasks and report having better PM than before training. Results from diary entries, reports on forgetful moments and user reactions were also presented. Our findings suggest several design implications for digital memory training tools and directions for future research that could potentially bring benefit to older adults in terms of strengthening memory and improving independence.

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A TASK LIST

Figure 8 shows our naturalistic task list:

Time-Based Tasks

No.	Category	Task Instruction	Event Message	Intention Sentence
1	Finance Manangement	In *?* minutes, TRANSFER money to your BANK ACCOUNT through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will *?* to my BANK ACCOUNT through BEGIN TASK.
2		In *?* minutes, CHECK the balance in your BANK ACCOUNT through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will *?* in my BANK ACCOUNT through BEGIN TASK.
3		In *?* minutes, TOP-UP your TRANSPORT CARD through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will *?* my TRANSPORT CARD through BEGIN TASK.
4		In *?* minutes, CHECK the balance in your TRANSPORT CARD through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will *?* in my TRANSPORT CARD through BEGIN TASK.
5		In *?* minutes, PAY for your PARKING through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will *?* my PARKING through BEGIN TASK.
6		In *?* minutes, CHECK your PARKING fees through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will *?* my PARKING fees through BEGIN TASK.
7	Communication	In *?* minutes, EMAIL researcher about your favourite travel destination.	-	When I am at (location) *?* at (time) *?*, then I will *?* researcher about my favourite travel destination.
8		In *?* minutes, EMAIL researcher about a good TV show that you have watched.	-	When I am at (location) *?* at (time) *?*, then I will *?* researcher about a good TV show that I have watched.
9		In *?* minutes, EMAIL researcher about your favourite hobby.	-	When I am at (location) *?* at (time) *?*, then I will *?* researcher about my favourite hobby.
10		In *?* minutes, EMAIL researcher about a good book that you have read.	-	When I am at (location) *?* at (time) *?*, then I will *?* researcher about a good book that I have read.
11		In *?* minutes, EMAIL researcher to remind to buy chocolates.	-	When I am at (location) *?* at (time) *?*, then I will *?* researcher to remind to buy chocolates.
12		In *?* minutes, EMAIL researcher to tell about your day.	-	When I am at (location) *?* at (time) *?*, then I will *?* researcher to tell about my day.
13	Lifestyle Management (Booking & Sign-Ups)	In *?* minutes, make a FLIGHT BOOKING through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will *?* through BEGIN TASK.
14		In *?* minutes, make a BOOKING to watch a FILM through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will *?* through BEGIN TASK.
15		In *?* minutes, make a BOOKING to watch a THEATRE performance through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will *?* through BEGIN TASK.
16		In *?* minutes, SIGN-UP for a club MEMBERSHIP through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will sign-up *?* through BEGIN TASK.
17		In *?* minutes, SIGN-UP for a WORKSHOP through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will sign-up *?* through BEGIN TASK.
18		In *?* minutes, SIGN-UP as a VOLUNTEER through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will sign-up *?* through BEGIN TASK.
19	Shopping & Heatlh Management	In *?* minutes, order from GROCERIES DELIVERY through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will order *?* through BEGIN TASK.
20		In *?* minutes, order from FLOWERS DELIVERY through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will order *?* through BEGIN TASK.
21		In *?* minutes, order from PIZZA DELIVERY through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will order *?* through BEGIN TASK.
22		In *?* minutes, order from APPLIANCES DELIVERY through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will order *?* through BEGIN TASK.
23		In *?* minutes, arrange an APPOINTMENT with your DOCTOR for a health check-up through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will arrange an APPOINTMENT with *?* through BEGIN TASK.
24		In *?* minutes, arrange an APPOINTMENT with your DENTIST through BEGIN TASK	-	When I am at (location) *?* at (time) *?*, then I will arrange an APPOINTMENT with *?* through BEGIN TASK.

Event-Based Tasks

No.	Category	Task Instruction	Event Message	Intention Sentence
25	Finance Manangement	TRANSFER money to your BANK ACCOUNT through BEGIN TASK when you see that "You have just returned home"	You have just returned home	When I (event) *?*, then I will *?* to my *?* through BEGIN TASK.
26		CHECK the balance in your BANK ACCOUNT through BEGIN TASK when you see that "You are about to leave the house"	You are about to leave the house	When I (event) *?*, then I will *?* in my *?* through BEGIN TASK.
27		TOP-UP your TRANSPORT CARD through BEGIN TASK when you see that "You are about to leave the house"	You are about to leave the house	When I (event) *?*, then I will *?* my *?* CARD through BEGIN TASK.
28		CHECK the balance in your TRANSPORT CARD through BEGIN TASK when you see that "You have just returned home"	You have just returned home	When I (event) *?*, then I will *?* in my *?* CARD through BEGIN TASK.
29		PAY for your PHONE BILLS through BEGIN TASK when you see that "You have just returned home"	You have just returned home	When I (event) *?*, then I will *?* my *?* bills through BEGIN TASK.
30		CHECK your PHONE BILLS through BEGIN TASK when you see that "You are about to leave the house"	You are about to leave the house	When I (event) *?*, then I will *?* my *?* bills through BEGIN TASK.
31	Communication	EMAIL researcher to tell about your day when you see that "You have just returned home"	You have just returned home	When I (event) *?*, then I will *?* researcher about *?*.
32		EMAIL researcher to remind of your next meeting with him/her when you see that "You are about to leave the house"	You are about to leave the house	When I (event) *?*, then I will *?* researcher to remind *?*.
33		EMAIL researcher to remind to pay for apartment fees when you see that "You are about to leave the house"	You are about to leave the house	When I (event) *?*, then I will *?* researcher to remind *?*.
34		EMAIL researcher about the best advice you have heard when you see that "You have just returned home"	You have just returned home	When I (event) *?*, then I will *?* researcher about *?* .
35		EMAIL researcher about your favourite song when you see that "You have just returned home"	You have just returned home	When I (event) *?*, then I will *?* researcher about *?* .
36		EMAIL researcher about a good film that you have watched when you see that "You are about to leave the house"	You are about to leave the house	When I (event) *?*, then I will *?* researcher about *?*.
37	Lifestyle Management (Booking & Sign-Ups)	Make a FLIGHT BOOKING through BEGIN TASK when you see that "You are about to leave the house"	You are about to leave the house	When I (event) *?*, then I will *?* through *?*.
38		Make a BOOKING to watch a FILM through BEGIN TASK when you see that "You have just returned home"	You have just returned home	When I (event) *?*, then I will *?* through *?*.
39		Make a BOOKING to watch a THEATRE performance through BEGIN TASK when you see that "You have just returned home"	You have just returned home	When I (event) *?*, then I will *?* through *?*.
40		SIGN-UP for a club MEMBERSHIP through BEGIN TASK when you see that "You have just returned home"	You have just returned home	When I (event) *?*, then I will *?* for a *?* through BEGIN TASK.
41		SIGN-UP for a WORKSHOP through BEGIN TASK when you see that "You are about to leave the house"	You are about to leave the house	When I (event) *?*, then I will *?* for a *?* through BEGIN TASK.
42		SIGN-UP as a VOLUNTEER through BEGIN TASK when you see that "You are about to leave the house"	You are about to leave the house	When I (event) *?*, then I will *?* as a *?* through BEGIN TASK.
43	Shopping & Heatlh Management	Later, during your 1h slot, you will be asked to go to the online BOOK SHOP through BEGIN TASK and you will see a list of books to buy. While purchasing the books on the buying list, remember to buy "The Memory Book by Harry Lorayne and Jerry Lucas" as well.	Go to the BOOK SHOP and start your shopping now	When I am buying the *?* on the buying list in the online *?* SHOP, then I will buy the *?* as well.
44		Later, during your 1h slot, you will be asked to go to the online GIFT SHOP through BEGIN TASK and you will see a list of gifts to buy. While purchasing the gifts on the buying list, remember to buy the "Flashlight" as well.	Go to the GIFT SHOP and start your shopping now	When I am buying the *?* on the buying list in the online *?* SHOP, then I will buy the *?* as well.
45		Order from PIZZA DELIVERY through BEGIN TASK when you see that "You have just returned home"	You have just returned home	When I (event) *?*, then I will *?* through *?* DELIVERY in BEGIN TASK.
46		Order from FLOWERS DELIVERY through BEGIN TASK when you see that "You are about to leave the house"	You are about to leave the house	When I (event) *?*, then I will *?* through *?* DELIVERY in BEGIN TASK.
47		Arrange an APPOINTMENT with your DOCTOR for a health check-up through BEGIN TASK when you see that "You are about to leave the house"	You are about to leave the house	When I (event) *?*, then I will *?* with my *?* through BEGIN TASK.
48		Arrange an APPOINTMENT with your DENTIST through BEGIN TASK when you see that "You have just returned home"	You have just returned home	When I (event) *?*, then I will *?* with my *?* through BEGIN TASK.

Fig. 8. Task List of 48 tasks classified into categories, includes associated task instructions, event messages and intention sentences